Precision Fusion Measurements with a High Efficiency Superconducting Solenoidal Separator

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High precision measurements of fusion are an essential step in investigating the effects of coherent and dissipative processes on quantum tunneling of complex nuclei [1,2]. Fusion reactions are initiated in the laboratory by energetic ion beams impinging on a target. The beam and target nuclei fuse to form a “hot” compound nucleus which de-excites by particle emission, forming evaporation residues (ERs). The ERs exiting the target are peaked around 0˚. The elastically scattered beam particles are also forward focused and can be up to 10^5 times more intense than the ERs. In order to measure ERs in the presence of the intense background of elastically scattered particles, the latter has to be spatially separated and prevented from entering the detection system. A 6.5 T superconducting solenoidal separator, SOLITAIRE, has been developed [3] at the ANU to enable this separation. In SOLITAIRE, the beam particles and evaporation residues enter a magnetic field region, filled with low pressure Helium gas. Charge changing collisions cause the ions to travel with an average charge state. The high axial magnetic field of the solenoid transports the elastically scattered particles back to the beam axis, where they are stopped, and thus prevented from entering the detector system. The evaporation residues, due to their larger magnetic rigidity, are focused at a further point outside the solenoid, where they are detected using two position sensitive multi-wire proportional counters (MWPCs). The large angular acceptance makes SOLITAIRE an extremely efficient device not only for fusion measurements, but also for implantation studies in materials.

The determination of absolute fusion cross-sections requires an accurate knowledge of the transmission efficiency of evaporation residues through the solenoid, which in turn depends critically on the angular distribution of ERs exiting the target. The ER angular distribution can be obtained by two methods: (i) from the radial distribution of the ERs measured at the position of the MWPCs and (ii) from the measured velocity distributions of the evaporation residues. Measurements for both (i) and (ii) can be made simultaneously in our experiment, and thus we can investigate the relative merits and reliability of these two methods in determining ER angular distributions. The poster will present these investigations and demonstrate that velocity distribution measurements provide the most reliable measure of angular distributions. The angular distributions thus determined can be used to calculate the ER transmission efficiency through the solenoid. Demonstration of the reliability of this new method is an essential element in the research program to study the tunneling of complex quantum nuclear systems.

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[3] M.D. Rodŕiguez *et al.*, Nucl. Instr. and Meth. A 614, 119 (2010).